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SURVIVING THE TITANIC DISASTER: ECONOMIC, NATURAL AND SOCIAL DETERMINANTS

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Abstract:

The sinking of the Titanic in April 1912 took the lives of 68 percent of the people aboard. Who survived? It was women and children who had a higher probability of being saved, not men. Likewise, people traveling in first class had a better chance of survival than those in second and third class. British passengers were more likely to perish than members of other nations.
This extreme event represents a rare case of a well-documented life and death situation where social norms were enforced. This paper shows that economic analysis can account for human behavior in such situations.

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I. Introduction

During the night of April 14, 1912, the *Titanic* collided with an iceberg on her maiden voyage. Two hours and forty minutes later she sank, resulting in the loss of 1,517 lives—more than two-thirds of her 2,207 passengers and crew.[1] This remains one of the deadliest peacetime maritime disasters in history and by far the most famous.[2] It is one of those rare events that are imprinted on human memory, like President Kennedy's assassination, the first moon landing, and the terrorist attacks on the Twin Towers on 9/11. The disaster came as a great shock to many because the vessel was equipped with the most advanced technology at that time, had an experienced crew, and was thought to be (practically) "unsinkable."[3]

The myths surrounding the *Titanic* disaster were kept alive by the many attempts to find her wreckage. It was not until 1985 that a joint American-French expedition, led by Jean-Louis Michel and Dr. Robert Ballard, located the wreckage and collected approximately 6,000 artifacts, which were later shown in a successful exhibition that toured the world.

The *Titanic*'s fame was enhanced by the considerable number of films made about it, especially the 1997 production of *Titanic*, which was directed by James Cameron and starred Leonardo DiCaprio and Kate Winslet.[4] It was (at the time) the most expensive film ever made, costing approximately US$200 million, and was funded by Paramount Pictures and 20th Century Fox. The film was a major commercial and critical success. It is the highest grossing film of all time, earning US$1.8 billion, and it won eleven Academy Awards, tying with *Ben Hur* and *The Lord of the Rings: The Return of the King* for the most Oscars won by a movie.

The extent of the tragedy is mainly because there were too few lifeboats on the *Titanic*. The vessel carried only 20 lifeboats, which could accommodate 1,178 people, or 52 percent of the people aboard.[5] As the *Titanic* did not show any signs of being in imminent danger, passengers were reluctant to leave the apparent security of the

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[1] For accounts of the disaster, see, for example, Lord (1955, 1986), Eaton and Haas (1994), Quinn (1999) and Ruffman (1999), as well as the *Encyclopedia Titanica* (www.encyclopedia–titanica.org) and the information provided by RMS Titanic, Inc. that were granted "salvor-in-possession" rights to the wreck by the U.S. District Court for the Eastern District of Virginia (www.titanic-online.com).

[2] The *Titanic*'s death toll was exceeded by the explosion and sinking of the steamboat *Sultana* on the Mississippi River in 1985 when 1,700 people perished. The worst peacetime maritime disaster happened in 1987 when the passenger ferry *Doña Paz* collided with an oil tanker and caught fire. The sinking of the ferry claimed between 1,500 and 4,000 lives. However, the worst maritime disasters happened during wartime. For instance, the sinking of the *Wilhelm Gustloff* by Soviet submarines in January 1945 caused the deaths of between 7,000 and 9,000 people. The *Titanic* is not the only major vessel that did not survive her maiden voyage. The British RMS *Tayleur* in 1854 and the Danish *Hans Hedthoft* in 1995 were also technically innovative vessels that sank on their first trip. The famous *Gustav Vasa* met with the same fate in 1628; it capsized while still in port at Stockholm.

[3] In contrast to popular mythology, the *Titanic* was never described as "unsinkable" without qualification. The notion entered the public's consciousness only *after* the sinking (see Howell 1999). See, in general, Tierney (2006).

[4] For example, *Saved from the Titanic* (1912), *In Nacht und Eis* (1912), *Atlantic* (1929), *Titanic* (1943 and 1953), *A Night to Remember* (1958), *Raise the Titanic!* (1980). In addition, there were several TV movies and series.

[5] There were more lifeboats than required by the rules of the British Board of Trade, which were drafted in 1894 and which determined the number of lifeboats required by a ship's gross register tonnage, rather than the number of persons aboard.

vessel to board small lifeboats. The panicking deck crew exacerbated the situation further at the beginning by launching lifeboats that were partially empty. As a consequence, there was an even greater demand for lifeboat places when the remaining passengers finally realized that the ship was indeed sinking. People struggling to survive had to compete with other people aboard for a place in the few remaining lifeboats. Failure to secure a seat virtually guaranteed death because the average ocean temperature was about 2 degrees Celsius (35 degrees Fahrenheit); any survivors of the sinking vessel left in the water would have quickly frozen to death. Only a handful of swimmers were rescued from the water.[6]

Our paper analyzes the determinants of who is more likely to survive such a tragic event. This is an interesting issue in itself as the probability of survival differs greatly between individuals. For example, according to the official casualty figures, men traveling first class were much more likely to survive than men in second and third class, and nearly all women traveling in first class survived compared to women traveling in the other two classes.[7] Yet, the *Titanic* disaster is also relevant in a more general context. It allows us to analyze behavior under extraordinary conditions, namely in a life and death situation. Do human beings behave more in line with the selfish *homo oeconomicus*, where everybody is out for himself or herself and possibly even puts other people's lives in danger? If that were the case, we would expect that physically stronger people, that is, adult males, would have a higher probability of survival than women, children, and older people. Otherwise, when it comes to a life or death decision, are human beings capable of unselfishness and perhaps even chivalrous behavior? The answer to this question is open.[8] Some economists argue that the tendency to act selfishly arises when the stakes are high; in particular, when survival is at stake. Other economists are less certain.[9] In contrast, sociobiologists argue that under such circumstances genetic influences become more powerful, resulting in more women of childbearing age being saved than those not of childbearing age or men. The study of the sinking of the *Titanic* may also have major policy consequences beyond what was implemented shortly after the disaster.[10] Thus, provided unselfish behavior can be identified, the question then becomes—Do more stringent safety regulations crowd out intrinsically moral behavior, and could they possibly lead to worse outcomes than less strict regulations? The data available to us can be considered to be the outcome of a quasi-natural experiment; the disaster occurred due to an exogenous event, and the resulting life and death situation affected all persons aboard equally. The tragic event occurred in a closed environment, undisturbed by the outside intervention of other agents.

[6] Anecdotal evidence taken from U.S. Senate Inquiry (1912).

[7] Titanic Disaster: Official Casualty Figures and Commentary (http://www.anesi.com/titanic.htm).

[8] Helping behavior has been shown to exist under particular circumstances; see, for example, Worman (1979), Batson et al. (1979), Amato (1990), Harrell (1994), and for a survey Eagly and Crowley (1986).

[9] This issue has been debated and experimentally analyzed in the context of high-stakes games. See, for example, Fehr et al. (2002), Camerer (2003), and Camerer and Fehr (2006). For life or death decisions, see more generally Howard (1979, 1980), Shepard and Zeckhauser (1984), Slonim and Roth (1998), and Smith and Keeney (2005).

[10] The sinking of the *Titanic* led to the first International Convention for the Safety of Life at Sea in London on November 12, 1913, resulting in a treaty that was to go into effect on July 1, 1915, but which was delayed by World War I. It established the International Ice Patrol to monitor and report on the location of North Atlantic icebergs that could pose a threat to shipping. In addition, it was agreed that all passenger vessels must have sufficient lifeboats for everyone aboard, safety drills must be instituted, and radio communication must be operated 24 hours a day.

We proceed by first developing the theoretically grounded hypotheses of what determined the survival probability of the people aboard the *Titanic*. Section II discusses the data we use, and Section III presents the econometric estimates, including various robustness tests. The first set of hypotheses relate to *economic determinants*. Our estimates suggest that the first-class passengers' income and wealth greatly helped in saving their lives as compared to the second-class passengers, and even more so the third-class passengers. The crew had access to more informational and relational resources and therefore had a higher survival chance than the passengers, in particular, the deck crew. The second set of hypotheses deal with *natural determinants*. We find that people in their prime (ages 15–35) had a higher chance of survival than older people. Women of reproductive age and women with children also had a higher probability of being rescued, which speaks for the sociobiological approach. The third set of hypotheses refers to various *social determinants* of survival. It seems that (at least to some extent) the social norm that "women and children first" was followed in this situation, overcoming completely selfish behavior. The British passengers did not, or could not, take advantage of being on a British ship; indeed, passengers from the USA had a higher survival probability than citizens of other nations. Section IV concludes by drawing general consequences for the behavior of human beings in life or death situations.

II. Theoretical Hypotheses about Who Is Expected To Be Saved

Economists have mainly studied the consequences of disasters by analyzing the effects for the short, medium, and long term, following the path-breaking contributions by Hirshleifer (1963) and Dacy and Kunreuther (1969).[11] Psychologists and sociologists, on the other hand, focus more on the behavior of people *during* disasters. Much of the latter literature rejects the idea that during a disastrous event many people are stunned, become immobilized, and are unable to act rationally (the so-called "disaster syndrome"). This literature also rejects the concept that in the event of a disaster chaos, panic, social breakdown, and antisocial behavior, such as crime, looting, or exploitation, often occur. Indeed, it has been found that morals, loyalty, respect for law and customs, and tenets of acceptable behavior do not instantly break down with a disaster.[12] This is consistent with the empirical evidence accumulated in behavioral economics (or economic psychology), which shows that people do not necessarily exploit an opportunity presented to them when it can hurt other people. Rather, they are often inclined to help other people. Substantial evidence has been generated that motives such as altruism, fairness, or morality affect the behavior of many individuals. People sometimes punish others who have harmed them or reward those who have helped them, sacrificing their own wealth (see Camerer et al. 2004). People donate blood or organs without being paid and give money for charitable purposes. In wartime, many individuals volunteer and are willing to take high risks as soldiers (see Elster 2007). Citizens vote in elections, incurring more private costs than benefits, and people are paying more taxes than a

[11] Other contributions are, for instance, De Alessi (1975), Sorkin (1982), Albala-Bertrand (1993), Grossi and Kunreuther (2005), and Kunreuther and Pauly (2005). Particular attention has been paid to insurance against natural disasters, for example, Kunreuther (1996) and Kunreuther and Roth (1998).
[12] See, for example, Quarantelli (1960, 1972), Johnson (1988), Drabek (1986), Johnson et al. (1994), Aguirre et al. (1998), Tierney et al. (2001), and Hancock and Szalma (2008).

traditional economics-of-crime model would predict (see Torgler 2007). Individuals also help others in many situations on the job (see Drago and Garvey 1998).[13]

For our purpose, we develop a simple theoretical framework that allows us to develop nine hypotheses (arranged according to whether they belong to what can be called "economic," "natural," or "social" factors) that can be tested using the data on who survived and who perished in the *Titanic* disaster. The factual knowledge about the conditions aboard the *Titanic* has been gathered from various sources, most importantly from the *Encyclopedia Titanica* and various official accounts as well as monographs.[14] The hypotheses should be understood in the *ceteris paribus* sense. They are not mutually exclusive, but can occur simultaneously. The theoretical framework is influenced by tournament theory (see Lazear and Rosen 1981; Nalebuff and Stiglitz 1983; and Kräkel 2008) and biological theories on efforts to understand fitness in a cooperative animal society, such as the wasp (see Cant and Field 2001).

Surviving the *Titanic* disaster can be modeled as a tournament with two risk averse contestants *i* and *j*. Survival (*s*) can be described as a production function $s_i = e_i + a_i$ and $s_j = e_j + a_j$[15] where *e* is the effort expended to save oneself, and *a* is the ability to do so. $s^1_{i,j}$ indicates that individual *i* or *j* survives and $s^0_{i,j}$ that the individual does not survive. The ability difference Δa between individual *j* and *i* is: $\Delta a = a_j - a_i$. We assume that $\Delta a \geq 0$. Exerting effort imposes costs on an individual, described by the function c(e_i) and c(e_j) with $c(0) = 0$, $c'(e_{i,j}) > 0$ and $c''(e_{i,j}) > 0$. The utility functions can be written as:

$$U_i(e_i) = p_i u_i(s^1_i) + (1 - p_i) u_i(s^0_i) - c(e_i) \tag{1}$$

$$U_j(e_j) = (1 - p_i) u_j(s^1_j) + (p_i) u_j(s^0_j) - c(e_j) \tag{2}$$

with $p_i = prob(s_i > s_j) = F(e_i - e_j - \Delta a)$. In other words, the probability is a cumulative distribution based on individual effort and ability difference (see Kräkel 2008). We normalize the utility of those persons not surviving to $u_i(s^0_i) = 0$ and $u_j(s^0_j) = 0$. Thus, we can reformulate equations (1) and (2) as:

$$U_i(e_i) = p_i u_i(s^1_i) - c(e_i) \tag{3}$$

$$U_j(e_j) = (1 - p_i) u_j(s^1_j) - c(e_j) \tag{4}$$

[13] See, for example, Meier (2006, 2007) for an extensive survey; Ledyard (1995), Camerer and Thaler (1995), Camerer (2003), and Frey and Meier (2004) specifically for voluntary contributions to public goods; and Eckel and Grossman (1996), Andreoni and Miller (2002), Henrich et al. (2001) for dictator and ultimatum games. Surveys on the related topic of fairness are provided, for example, by Fehr and Schmidt (1999), Camerer (2003), Konow (2003).

[14] Official British and American inquiries by The Wreck Commissioner's Court (1912) and The Committee on Commerce (1912).

[15] The production function is also affected by noise or random shocks, but we assume that both subjects are affected identically.

Agents choose their efforts in order to maximize equations (3) and (4). The first-order condition can be written as:

$$f(e_i^* - e_j^* - \Delta a)u_i^1 - c'(e_i^*) = 0 \qquad (5)$$

$$f(e_i^* - e_j^* - \Delta a)u_j^1 - c'(e_j^*) = 0 \qquad (6)$$

Equations (5) and (6) indicate that the flatter the density *f*(.), or in other words the higher the survival rate and the steeper the cost function, the lower the equilibrium effort of an agent will be. Moreover, the stronger the ability disadvantage, Δa, the higher the survival rate. On the other hand, the more *i* tries to generate a relative effort advantage, ($e_i^* - e_j^*$), the lower the survival rate. Furthermore, an individual's incentive to survive increases with an increase in the value of surviving because $\partial u_{i,j}^1 / \partial s_{i,j}^1 > 0$. In addition, an individual requires less effort to survive if his marginal costs are lower. These findings allow us to develop several testable hypotheses with regard to economic and natural determinants.

A. Economic Determinants (E)

The 1,316 passengers on the *Titanic* were divided into three different classes: 325 in first class, 285 in second class, and 706 in third class. It is to be expected that the first-class passengers tried to obtain the same preferential treatment with respect to lifeboat access that they generally received on the vessel. People with more income and wealth, such as first-class passengers, are more able to secure a place on a lifeboat than people of lesser economic means. Thus, they have a *relative ability* advantage compared to the second- and third-class passengers. They were used to giving orders to employees (in this case the crew), and they were better able to bargain, in the extreme case even offering financial rewards. They were also in closer contact with the upper echelon crewmembers (in particular, First Officer Murdoch, who commanded the loading of lifeboats on the starboard side, and Second Officer Lightoller, who did the same on the port side). Moreover, the first-class passengers had better access to information about the imminent danger and were aware that the lifeboats were located close to the first-class cabins. Thus, their marginal effort costs to survive were lower. In contrast, most third-class passengers had no idea where the lifeboats were located (safety drills for all passengers were introduced after the *Titanic* disaster), and they did not know how to reach the upper decks where the lifeboats were stowed. A relative advantage in the ability, the effort, and the marginal costs raises the probability of survival, leading to the following hypotheses:

Hypothesis E1: First-class passengers have a higher probability of survival than second-class passengers; second-class passengers, in turn, have a higher probability of survival than third-class passengers.

One would expect the experienced crew of 886 men and women to be better prepared for a catastrophic event, to be earlier and better informed about the location of lifeboats and the danger of sinking, and to have closer personal contacts with the crewmembers in charge of loading the lifeboats. This gives them a relative advantage over passengers regarding saving their own lives (relative ability and effort/cost advantage). On the other hand, it is their duty to help save passengers, and they are only supposed to abandon a sinking ship when that task has been fulfilled. We expect that in life or death situations, such as that encountered on the *Titanic*, selfish interests tend to dominate.

Hypothesis E2: Crewmembers have a higher probability of survival than passengers.

Not all crewmembers benefited from the same favorable conditions. Some of the conditions just mentioned are more likely to apply to the deck crew (who was, for instance, in charge of manning the lifeboats) or the engine crew (who had information about the damage done to the ship). The crew directly responsible for passenger amenities (victualing and a la carte crew) did not have the same information as the deck and engine crews. Therefore, the deck and engine crewmembers could use their comparative advantage to increase their chances of survival. We may also observe a "closeness effect." The officers directing the loading of the lifeboats and deciding which crew went with which boat were members of the deck crew. They would have been somewhat biased towards those of their own work group.

Hypothesis E3: The deck and engine crewmembers have a higher chance of survival than other crewmembers.

B. Natural Determinants (N)

Based on the theoretical framework, we are also able to cover natural (biological) determinants. In the situation of a large excess demand for places in the lifeboats, a selfish *homo oeconomicus*, faced with life or death, would fight to be able to board a lifeboat. People with greater physical strength, that is, people in their prime, would have an advantage over older people in the fight for survival. Physical strength is correlated with higher ability and lower marginal effort costs in the event of such a disaster. Thus, we can develop the following hypothesis:

Hypothesis N1: People in their prime have a higher chance of survival than older people.

As a next step, let us assume that some people onboard the *Titanic* make the effort to help others survive. For example, let us assume that *j* is willing to help *i* and that the utility function depends on the level of relatedness (*r*) between individuals, where $\partial u_{i,j} / \partial r_{i,j} > 0$. Moreover, we assume that *j* is prepared to make additional efforts to help *i* (e.g., due to moral costs). We define individual *i*'s fitness to survive without help as F_i^0 and individual *j*'s fitness to survive without helping as F_j^0. This model of helping behavior is similar to biological studies conducted on helping effort and fitness in cooperative animal societies (see Cant and Field 2001), assuming that individuals have interdependent preferences (see, e.g., Becker 1974; Sobel 2005). The fitness level of *j* due to helping *h* can be written as:

$$F_j^h = F_j^0 (1 - \gamma \text{ h}) \tag{7}$$

where h *is the level of* h *and* γ *the cost of helping (cost per unit of help extended). Thus,* F_j^h *is a decreasing function of* h*. The maximum possible level of help would be* 1/γ*, where* $F_j^h = 0$*.*

Individual *j*'s investment in *h* increases the survival probability of individual *i*. Helping investment, *I*(*h*), is subject to diminishing benefits in terms of efficiency so that *I*(*h*) is a positive but decelerating function of *h*. The level of investment is taken to be driven by society's helping norms, *n* (e.g., "women and children first"). Thus, the helping investment, *I*(*h*), can be written as:

$$I(h) = n(1 - e^{-qh}) \tag{8}$$

where q *determines how rapidly the marginal investment of help diminishes. This allows us to define new utility functions for i and j*:

$$U_j^h = F_j^h + r\, I(h) \tag{9}$$

$$U_i^h = F_i^0 + I(h) + r\, F_j^h \tag{10}$$

The utility function of individual *i*(*j*) is positively correlated with a higher survival rate of *j*(*i*), which means that preferences are interdependent. Substituting equations (7) and (8) with (9) and (10) leads to:

$$U_j^h = F_j^0 (1 - \gamma h) + r\, n(1 - e^{-qh}) \tag{11}$$

$$U_i^h = F_i^0 + n(1 - e^{-qh}) + r\, F_j^0 (1 - \gamma h) \tag{12}$$

The optimal level of help is generated by maximizing equations (11) and (12) with respect to *h*. This leads to:

$$h_j^* = \frac{1}{q}\ln\left(\frac{nqr}{\gamma F_j^0}\right) \tag{13}$$

$$h_i^* = \frac{1}{q}\ln\left(\frac{nq}{\gamma r F_j^0}\right) \tag{14}$$

Equation (13) measures the optimal level of help from the perspective of the helper, *j*, and equation (14) from the perspective of the person being helped, *i*. They can be seen as an upper and lower limit. We observe that individual *j*'s optimal level of help increases with an increase in society's norm of helping (*n*) and the level of relatedness (*r*).

An alternative determinant of survival is based on sociobiology. It stresses the relevance of the "procreation instinct." As the survival of a species depends on its offspring, a high value must be placed upon females of reproductive age as a valuable resource. Social norms may be created to protect the reproductive and child-rearing role of women (higher *n*). It is an attempt to protect children rather than the result of a greater value put on women's lives. A potential shortage of women would limit the number of offspring, while a shortage of men would not (see Felson 2000). In humans, the period of peak reproduction is between the ages of 16 and 35 (see A.S.R.M. 2003). Females (on average) are not reproductively functional before age 15, and the reproductive cycle begins to slow down from age 35 to age 50 when the reproductive function is usually lost altogether. It has also been emphasized that the social norm of helping women may be related to the relative physical and structural vulnerability of women (see Felson 2000).

Females may also have a strong incentive to ensure the survival of their children in the event of a disaster like the *Titanic* (strong *r* relationship between child and mother). In anthropology, "parental investment" is an important concept. It argues that the females of most species invest more in ensuring the survival of their offspring than the males. The females of the species are the ones who are responsible for their young during gestation and lactation, and they generally protect them from predators and educate them (see Geary 1998). The male contribution is usually much smaller. Because of the much larger investment on the part of the females, the opportunity cost of losing offspring is higher and the drive to ensure offspring survival is stronger (see Campbell 1999). It has been shown that the mortality rates of children with a mother are 1.4 times lower than those without a mother (see Voland 1998) and that the survival rates of offspring can be directly linked to maternal survival (see Bjorklund and Shackelford 1999). Under these conditions, it is to be expected that females with children would be much more alert to possible danger and would aggressively fight other females to ensure a safe haven (see Cashdan 1997). Moreover, it has been emphasized that it is the parent who has the greater investment in promoting the survival of offspring who is the more valued resource (see Trivers 1972; Eswaran and Kotwal 2004).

These sociobiological considerations lead to the following two hypotheses:

Hypothesis N2: Women of reproductive age have a higher probability of survival due to being subject to a social norm of helping.

Hypothesis N3: Women with children have a higher probability of survival than women without children.

C. Social Determinant (S)

A key norm under life and death conditions is that women and children are to be saved first (higher *n*). This norm may work directly in the sense that men let women and children board the lifeboats first. The norm may also have been supported institutionally, thus it could have worked indirectly if the officers in charge of loading the lifeboats directed the male passengers to let women and children proceed first. Interestingly, there is no international maritime law that requires that women and children be rescued first. Similar norms can be found in other areas where people need to be evacuated. Humanitarian agencies often evacuate "vulnerable" and "innocent" civilians, such as women, children, and elderly people first. The Geneva Convention provides special protection and evacuation priority for pregnant women and mothers of young children (see Carpenter 2003). The following hypothesis tests whether this social norm was acted upon when the *Titanic* sank.

Hypothesis S1: Women and children have a higher probability of survival than men.

Passengers traveling alone may be expected to have a lower chance of survival in life and death situations because they are less likely to receive information indirectly and to obtain psychological and physical support from others (lower r). On the other hand, being alone makes decision making less cumbersome and conflictive (lower transaction costs), increasing the survival chance of all (lower γ). Following the (crude) *homo oeconomicus* concept centered on individualistic considerations, the advantage of being able to act alone and to only have to consider one's own best interests seems to prevail. Moreover, a higher r increases j's willingness to help i (e.g., one's partner), but also reduces a partner's incentive to request help.

Hypothesis S2: Passengers traveling alone have a higher probability of survival than those traveling in a group ($n \geq 2$).

The *Titanic* was built in Great Britain, operated by British subjects, and manned by a British crew.[16] It is to be expected that national ties were activated during the disaster and that the crew would give preference to British subjects, easily identified by their language (higher r). In contrast, passengers from other nationalities, in particular Americans, Irish, and Scandinavians would be at a disadvantage.

Hypothesis S3: British subjects have a higher chance of survival than people of other nationalities.

III、 The Data

The sinking of the RMS *Titanic* was a tragic event and resulted in a sorrowful loss of life. However, the event offers economic researchers an exceptional opportunity to control exogenous factors within a quasi-natural field experiment. The event itself is completely isolated, making the external shock applicable to every person aboard the ship and the exogenous factors the same for everyone. The event is such that every person is impacted by the shock and is unable to defer making a decision. Even if one chooses not to participate in the scramble for lifeboat seats, the outcome is the same as that of someone who does strive for a seat and fails. The great advantage of a natural field experiment is the randomization and realism. The participants do not know that their fate can be looked at as being the result of an (natural) experiment; their behavior is therefore unaffected (see Reiley and List 2008).

[16] Interestingly enough, the Ocean Steam Navigation Company, popularly known as the "White Star" line because of the white star appearing on the company flag, was under the management of the industrial giant, J.P. Morgan. Nevertheless, the public perceived the *Titanic* as being a British ship.

We have been able to construct a detailed dataset, despite the facts that the event occurred almost 100 years ago and the records were not very detailed. Our data consist of 2,207 persons who were confirmed to be aboard the R.M.S. *Titanic*. The data were gathered from the *Encyclopedia Titanica* and crosschecked with other sources.[17] Summary statistics of the variables collected are reported in the Appendix (see Table A1). The dependent variable is whether someone survived or not. Out of 2,207 passengers and crewmembers, 1,517 people died. Based on the records, we were able to gather information about the gender, age, nationality, port where people boarded the *Titanic*, ticket price and therefore the passenger-class status (first, second, or third class). In addition, we were able to generate individual information related to travel plans and companions. Limited information was available with regard to the cabin allocation (only 15.2 percent).[18] Of the 2,207 persons onboard, the age of all but 21 individuals is known. Thus, using age in the regression reduces the number of observations to 2,186 persons (see Table A1).[19] Out of the 2,186 people onboard, 1,300 were passengers and 886 crewmembers. Among the passengers, 43 were servants. Additionally, of the 2,186 aboard, 1,704 were male (78 percent), and 460 of the 1,300 passengers were female (35 percent).

We have complete information on each person's country of residence (nationality). From this, we have been able to generate several variables to investigate the effects of nationality. We have created dummies for the most populous national groups aboard the *Titanic*. These include Great Britain (the largest group), Ireland, Sweden, the USA, and a group for all other nationalities. Passenger groupings have been identified by anecdotal evidence taken from family histories and known travel arrangements, ticket numbers, and cabin allocations.[20]

Because the impact of age is prominent in this investigation, it is important to use generally accepted groupings: children, adults, and older people. The United Nations standard for age, which classifies children as being fifteen years of age or under, is used. Among the 2,186 people aboard, 124 were children (65 girls and 59 boys). Adulthood begins post childhood and ends at old age, defined by the British Royal Commission in 1894 as beginning at age 50.[21] In humans, the peak reproductive age, as defined by the A.S.R.M., is between 15 and 35 years of age. There were 280 women out of the 2,186 people aboard between 16 and 35 years of age.

While there is some anecdotal conjecture that there may have been other people aboard (stowaways), the list of survivors corresponds to the "official" passenger lists.[22]

[17] The cross-checked resources include: Beavis (2002), Bryceson (1997), Committee on Commerce (1912), Eaton and Hass (1994), Geller (1998), Howell (1999), Lord (1955), Lord (1986), NSARM (2008), Quinn (1999), Ruffman (1999), U.S. National Archives (2008), Wreck Commissioner's Court (1912).

[18] The data also indicate that this information has been mainly provided by the survivors and is therefore biased. Moreover, as the iceberg was struck shortly before midnight, some passengers were not yet in their cabins, but somewhere else on the ship.

[19] Out of these 21 people, four were crewmembers and 17 passengers.

[20] Those passengers for whom there is no clear or known evidence were assumed to be traveling alone and assigned as single.

[21] The British Royal Commission was based upon the payment of benefits from the friendly societies (unions) to its members who were too old to work; these benefits began at age 50. The Commission accepted the reasoning and adopted this for government-aged welfare.

[22] This suggests that the unlisted "illegal" passengers did not survive and may not have competed with "official" passengers for lifeboat spaces.

IV、 Econometric Estimates and Results

The nine hypotheses developed are empirically tested using probit estimates. The tables below show the estimated parameter and the significance level (indicated by *z*-values). The respective marginal effects are also indicated. Table 1 deals with the economic and natural determinants and Table 2 with the social determinants.

A. Testing Economic Determinants

Table 1 presents the results of the first set of hypotheses, those relating to *economic determinants.*

Table 1 about here

The estimates are consistent with the hypotheses. According to equation (1), passengers in first class had a higher chance of survival than those in second class, and second-class passengers had a higher chance of survival than those in third class. The marginal effects suggest that a passenger in the highest class was 40 percent more likely to survive the catastrophe than a passenger in third class. A second-class passenger had a 16 percent higher chance of survival than somebody traveling in third class. These are large and robust differences. Adding controls for the gender composition of the various classes (equation 2) as well as possible effects of the crew (equation 3) has practically no impact on these marginal effects. Thus, hypothesis E1 cannot be rejected.

Estimation equation (3) indicates that the crew had an 18 percent higher chance of survival than the passengers, controlling for passenger class and gender. This result is consistent with the second economic hypothesis (E2).

Consistent with hypothesis E3, the survival rate is higher among deck and engine crewmembers than among members of the rest of the crew. In particular, the deck crew were more likely to save themselves than other crewmembers. According to equation (4), the deck crew had a much higher (74 percent) chance of survival, compared to 39 percent for the engine crew and 32 percent for the victualing crew (always compared to the remaining crew).

B. Testing Natural Determinants

Table 1 also shows the results obtained with respect to the *natural (sociobiological) determinants* of surviving the catastrophe. Passengers in their prime (16 to 35 years of age) had an 18 percent higher chance of surviving the disaster (equation 5) than older people. These results are consistent with hypothesis N1. In line with the sociobiological hypotheses N2 and N3, females of childbearing age (16–35) had a 15 percent higher probability of survival than older women (equation 8). In addition, if these women had a child, their survival probability was further increased by 16 percent (equation 7).

C. Testing Social Determinants

Table 2 shows the social determinants of survival.

Table 2 about here

Equation (8) suggests that being a female or child had a highly significant positive effect on being saved. The probability of surviving is 53 percent higher for females than for males and 15 percent higher for children than for adults (i.e., age 16 and above). The same effect can be observed for the crew where females even had a 64 percent higher chance of being saved (equation 9). These results are consistent with hypothesis S1, suggesting that social norms were to some extent observed even under conditions of extreme duress.

Being aboard the *Titanic* as a single person did not increase the chance of survival (see equation 10). The advantage of lower transaction costs in the decision-making process when traveling alone may have been overshadowed by psychological or even physical disadvantages and a lack of information. Thus, we can reject hypothesis S2.

Similarly, hypothesis S3 is refuted. As can be seen in equation 11, British subjects had a 10 percent lower chance of survival than passengers from other countries. This may be because the norms of being a "gentleman," even under extreme duress, were valid at that time in Britain. Estimation (12) shows that passengers from the USA had a 12 percent higher probability of survival than British subjects.

The last equation (13) in Table 2 includes all the social determinants. It is presented to indicate that the estimated parameters and marginal effects are quite robust. They are of similar magnitude, independent of which further determinants are included in the estimate.

A second test of the robustness of the estimated parameters is presented in Table 3.

Table 3 about here

Instead of splitting up the sample of persons aboard the *Titanic* as in Tables 1 and 2, Table 3 considers the complete sample and then captures the influence of gender by using interaction effects. As can be seen, the estimates are robust when the additional determinants relating to the crew, the reproductive age of women, and children are added. The qualitative results and the statistical significance remain unchanged when compared to the estimates in Tables 1 and 2. The most comprehensive estimate presented in equation (17) suggests that the survival probability more than doubles in its magnitude for women traveling in first class compared to males traveling in third class. Similarly, females traveling in second class have a 67 percent higher probability of surviving the disaster than our base group of third-class males. Men traveling in first class had a 30 percent higher chance of surviving than men traveling in third class, but there is no statistically significant difference between men traveling in second or third class.

A female member of the crew had a 59 percent higher probability of surviving the disaster than the male members of the crew and a 77 percent higher probability of surviving than non-crew male members. Female crewmembers have a 57 percent higher survival probability than non-crew women. In addition, male crewmembers had an 18 percent higher chance of survival than male non-crew members.

Women of reproductive age had a higher survival chance than males and females in other age categories. Female (male) children had a 77 percent (14 percent) higher probability of surviving than adults. Moreover, female children had a 62 percent higher survival probability than male children. Finally, those from the USA had a 9 percent higher chance to save themselves than the British.

In summary, the robustness test using interaction variables yields results consistent with all the hypotheses except S2.[23] British passengers were less likely to try to save themselves than those from any other nation; this corresponds to the estimates presented in Table 2.

V. Conclusions

The econometric estimates of the factors determining survival during the sinking of the *Titanic* produce a coherent story. However, this story is not necessarily in line with the simple model of selfish *homo oeconomicus.* While people in their prime were more likely to be saved, it was women—rather than men—who had a better chance of being saved. Children also had a higher chance of surviving. At the time of the disaster, the unwritten social norm of "saving women and children first" seems to have been enforced.

There is also support for sociobiological explanations of who was saved and who perished. Women of reproductive age and women with children had a higher probability of being saved.

However, we do find evidence suggesting that the effects predicted using the standard *homo oeconomicus* model are also important. People in their prime drowned less often than older people. Passengers with high financial means, traveling in first class, were better able to save themselves as were passengers in second class (compared to third class). Crewmembers who had access to better informational and relational resources managed to survive more often than others aboard. This applies in particular to the deck crew who were partly in charge of the rescue operations. In contrast, the British passengers who were the same nationality as most of the crewmembers did not take advantage of this fact. They had a higher probability of perishing than other nationalities, thus exhibiting behavior consistent with the prevailing concept of being a gentleman.

The sinking of the *Titanic* represents a rare case of a well-documented and most dramatic life and death situation. However, even under these extreme situations, the behavior of human beings is not random or inexplicable, but can be accounted for by economic analysis.

[23] As argued above, many passengers were not yet in their cabins when the *Titanic* struck the iceberg. Those situated in first-class cabins, however, were closer to the lifeboats than passengers in second or third class. Unfortunately, there are only very sketchy data on where the cabins of those passengers on which we have data were located on the *Titanic*. We could only collect the respective information, and therefore the distance to the lifeboats in meters for 325 persons of which 64 percent survived. As the overall survival rate is 32 percent, this sample is likely to be highly skewed; that is, the information on the distance to the lifeboats comes predominantly from passengers who were saved. Nevertheless, even using this questionable and small sample, the estimates of the determinants discussed remain robust: the effects of gender, cabin class, and reproductive age remain statistically significant and of similar magnitude as in Tables 1 and 2.

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Table 1
Economic and Natural Determinants of Survival

Probit	Passenger (1)	Passenger (2)	All (3)	Crew (4)	Adult Passenger All (5)	Adult Female Passenger (6)	Adult Female Passenger (7)
1st Class	0.990***	1.020***	1.023***		1.309***	2.156***	2.158***
z-value	11.24	10.32	10.33		10.76	8.25	8.07
marg.effect	0.378	0.387	0.387		0.484	0.43	0.417
2nd Class	0.408***	0.368***	0.368***		0.318**	1.060***	1.068***
z-values	4.46	3.59	3.58		2.79	5.59	5.57
marg.effect	0.158	0.14	0.136		0.119	0.211	0.204
Female		1.485***	1.509***	2.097***	1.641***		
z-value		17.7	18.59	6.1	17.69		
marg.effect		0.536	0.547	0.694	0.581		
Female Age 16–35						0.528**	0.572**
z-value						2.83	3
marg.effect						0.15	0.159
Female Age 16–35					0.512***		
z-value					4.66		
marg.effect					0.177		
Crew			0.496***				
z-value			6.21				
marg.effect			0.176				
Deck Crew				2.322***			
z-value				6.47			
marg.effect				0.744			
Engine Crew				1.211***			
z-value				3.65			
marg.effect				0.385			
Victualing Crew				1.091**			
z-value				3.32			
marg.effect				0.319			
Has Child /Children							0.937*
z-value							2.05
marg.effect							0.158
Obs.	1300	1300	2186	886	1178	401	401
Prob.>chi2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Pseudo R2	0.076	0.276	0.203	0.12	0.328	0.249	0.26

Notes: Dependent variable: Survival (value=1). The symbols *, **, *** represent statistical significance at the 5, 1, and 0.1% levels, respectively. Adult=Age>15. In the reference group: THIRD CLASS, MALE, PASSENGER (EQ3), A LA CARTE CREW (EQ4), AGE>36 (EQ5), FEMALE AGE>35 (EQ6 & EQ7), NOT HAVING A CHILD/CHILDREN (EQ7).

Table 2
Social Determinants of Survival

Probit	Passenger (8)	Crew (9)	Passenger (10)	Passenger (11)	Passenger (12)	All (13)
Female	1.468***	1.858***	1.456***	1.444***	1.447***	1.475***
z-value	17.44	5.50	16.77	16.58	16.41	17.38
marg.effect	0.53	0.64	0.526	0.522	0.523	0.536
Age Sub 15 (Children)	0.382**		0.807***	0.808***	0.821***	0.754***
z-value	2.83		3.93	3.91	3.96	3.78
marg.effect	0.148		0.313	0.313	0.318	0.289
Age 16–50			0.470**	0.476**	0.479**	0.422**
z-value			2.99	3.01	3.03	2.86
marg.effect			0.161	0.162	0.163	0.132
1st Class	1.066***		1.140***	1.122***	1.075***	1.072***
z-value	10.62		10.75	10.55	9.00	9.09
marg.effect	0.403		0.429	0.423	0.406	0.404
2nd Class	0.387***		0.407***	0.500***	0.471***	0.451***
z-value	3.74		3.90	4.51	4.10	3.97
marg.effect	0.148		0.155	0.191	0.180	0.168
Traveling Alone			-0.057	-0.070	-0.078	-0.071
z-value			-0.62	-0.76	-0.84	-0.77
marg.effect			-0.021	-0.026	-0.029	-0.024
England (1,143)				-0.268*		
z-value				-2.56		
marg.effect				-0.096		
Ireland (114)					0.238	0.180
z-value					1.37	1.10
marg.effect					0.091	0.065
Sweden (106)					0.090	0.053
z-value					0.52	0.31
marg.effect					0.034	0.019
USA (424)					0.309*	0.258*
z-value					2.49	2.39
marg.effect					0.116	0.093
All Others (399)					0.283*	0.237*
z-value					2.37	2.19
marg.effect					0.106	0.085
Crew						0.644***
z-value						5.47
marg.effect						0.228
Obs.	1300	886	1300	1300	1300	2186
Prob.>chi2	0.000	0.000	0.000	0.000	0.000	0.000
Pseudo R2	0.280	0.041	0.286	0.290	0.291	0.212

Notes: Dependent variable: Survival (value = 1). The symbols *, **, *** represent statistical significance at the 5, 1, and 0.1% levels, respectively. In the reference group: MALE, AGE>15 (EQ8), AGE >50 (EQ10-EQ13), THIRD CLASS, GROUP (couples with and without children and/or servants, singles with children and/or servants, extended group also covering friends), NOT FROM ENGLAND, (EQ11), ENGLAND (EQ12 & EQ13), PASSENGER (EQ13).

Table 3
Robustness Test Including Interaction Terms

Probit		All (14)	All (15)	All (16)	All (17)
Female		1.054***	0.942***	0.710***	0.532**
	z-value	9.86	8.21	4.61	3.17
	marg.effect	0.395	0.354	0.267	0.199
Age				-0.014***	-0.010*
	z-value			-4.36	-2.60
	marg.effect			-0.005	-0.003
1st Class		0.640***	0.603***	0.790***	0.777***
	z-value	4.96	4.65	5.71	5.59
	marg.effect	0.243	0.229	0.301	0.296
2nd Class		-0.008	-0.047	-0.008	-0.015
	z-value	-0.05	-0.32	-0.06	-0.10
	marg.effect	-0.003	-0.017	-0.003	-0.005
Crew		0.443***	0.377**	0.451***	0.492***
	z-value	3.85	3.22	3.76	4.04
	marg.effect	0.159	0.135	0.162	0.178
Ireland		0.268	0.294	0.223	0.245
	z-value	1.67	1.84	1.36	1.50
	marg.effect	0.100	0.110	0.082	0.091
Sweden		0.125	0.129	0.114	0.091
	z-value	0.74	0.77	0.68	0.54
	marg.effect	0.045	0.047	0.041	0.033
USA		0.242*	0.237*	0.259*	0.249*
	z-value	2.19	2.15	2.32	2.22
	marg.effect	0.088	0.087	0.095	0.091
All Others		0.238*	0.236*	0.184	0.175
	z-value	2.18	2.17	1.67	1.57
	marg.effect	0.087	0.086	0.067	0.064
Traveling Alone		-0.120	-0.136	-0.082	-0.032
	z-value	-1.34	-1.52	-0.89	-0.34
	marg.effect	-0.042	-0.047	-0.029	-0.011
Children					0.379*
	z-value				2.08
	marg.effect				0.143
1st Class* Female		1.118***	1.225***	1.337***	1.402***
	z-value	4.55	4.92	5.14	5.25
	marg.effect	0.424	0.459	0.494	0.513
2nd Class* Female		1.088***	1.197***	1.260***	1.284***
	z-value	4.95	5.35	5.53	5.56
	marg.effect	0.414	0.450	0.470	0.477
Crew* Female			0.906*	0.982**	1.034**
	z-value		2.53	2.77	2.93
	marg.effect		0.349	0.376	0.395
Reproductive Age* Female				0.334*	0.523**
	z-value			2.20	3.01
	marg.effect			0.124	0.199
Children* Female					1.118*
	z-value				2.48
	marg.effect				0.423
Obs.		2186	2186	2186	2186
Prob.>chi2		0.000	0.000	0.000	0.000
Pseudo R2		0.221	0.224	0.234	0.238

Notes: Dependent variable: Survival (value = 1). The symbols *, **, *** represent statistical significance at the 5, 1, and 0.1% levels, respectively. Reference group: Male, 3rd Class, England, Not Traveling Alone, Not a Child (EQ17).

Table A1
Summary Statistics

Variables	Mean	Std. Dev.	Min	Max	N
SURVIVED	0.320	0.467	0	1	2207
FEMALE	0.220	0.414	0	1	2207
AGE	30.044	11.610	1	74	2186
AGE< 16 (CHILDREN)	0.052	0.221	0	1	2186
AGE 16-50	0.891	0.312	0	1	2186
FEMALE 16-35	0.128	0.334	0	1	2186
1st CLASS	0.147	0.354	0	1	2207
2nd CLASS	0.129	0.335	0	1	2207
TRAVELING ALONE	0.217	0.412	0	1	2207
ENGLAND	0.527	0.499	0	1	2207
IRELAND	0.052	0.221	0	1	2207
SWEDEN	0.048	0.214	0	1	2207
USA	0.192	0.394	0	1	2207
OTHER NATIONALITIES	0.181	0.385	0	1	2207
CREW	0.403	0.491	0	1	2207

Sources: The Encyclopedia Titanica (2008) has been used as the primary source, which was crosschecked across the following resources: Beavis (2002), Bryceson (1997), Committee on Commerce (1912), Eaton and Hass (1994), Geller (1998), Howell (1999), Lord (1955), Lord (1988), NSARM (2008), Quinn (1999), Ruffman (1999), U.S. National Archives (2008), Wreck Commissioner's Court (1912).